

# SOME UPPER TRIASSIC REPTILES, FOOTPRINTS, AND AN AMPHIBIAN FROM NEW JERSEY

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## Abstract

Some significant discoveries of Upper Triassic tetrapods, all made by amateurs, are briefly recorded. 1. The first fossil amphibian specimen from New Jersey is the interclavicle of a labyrinthodont from the Stockton Formation near Princeton. Although unidentifiable to genus it represents the Metoposauridae, a cosmopolitan family of large, Late Triassic amphibians. 2. A stone wall in Passaic, built of Passaic Formation rocks, has yielded a fine skull of the procolophonid reptile *Hyposognathus fenneri*. Fossil footprints from the same source include *Gwyneddichnium* (here correlated with the tanytropheid eosuchian *Tanytrachelos*) and the first American record of *Procolophonichnium*. 3. The first phytosaur specimen from New Jersey, found in 1895 at Belleville, is a maxilla of *Rutiodon* from the Passaic Formation. It resembles that paleontological joke, *Palaeonornis struthionoides* Emmons (1857) from North Carolina, which was described as a Triassic bird sacrum but is actually a rostrum fragment of *Rutiodon*. Trackways named *Apatopus lineatus* and correlated with *Rutiodon* extend the range of phytosaurs into the upper part of the Passaic. 4. A partial skeleton and skull of the armored thecodont reptile *Stegomus arcuatus*, a juvenile individual from the Passaic Formation near Everittstown, permits the firm assignment of this genus to the Aetosauridae (= Stagonolepididae). It is distinguished from its European close relatives *Stagonolepis* and *Aetosaurus* by its rapidly tapering tail and the reduced sculpture on its dorsal armor plates.

## INTRODUCTION

It is no exaggeration to say that more than ninety percent of the significant discoveries of fossil vertebrates in New Jersey have been made by amateurs. This is certainly true for the Triassic Period, where rocks of the Stockton, Lockatong, and Passaic (formerly the Lower Brunswick) Formations have yielded a number of important finds over the years. In this paper I wish to put on record a few of the recent contributions made by amateurs, including specimens that will be analyzed in greater detail elsewhere, and document one nineteenth-century find that has been misunderstood and neglected. The specimens cited are preserved in the following institutions:

|      |                                                                       |
|------|-----------------------------------------------------------------------|
| AMNH | American Museum of Natural History, New York City                     |
| ANSP | Academy of Natural Sciences of Philadelphia                           |
| LC   | Lafayette College Geological Museum, Easton, Pennsylvania             |
| MCZ  | Museum of Comparative Zoology at Harvard College, Cambridge           |
| PU   | Princeton University Museum of Natural History (specimens now at YPM) |
| USNM | National Museum of Natural History, Washington                        |
| YPM  | Peabody Museum of Natural History, Yale University, New Haven         |

Grateful acknowledgements are due to the curators who have lent specimens for study and comparison, and especially to the enterprising collectors whose zeal and cooperative spirit have made these studies possible. Helpful information and criticism have been provided by Joseph T. Gregory, Donald Hoff, and Paul E. Olsen. This research was supported by the William Berryman Scott Fund of Princeton University.

## 1. THE FIRST METOPOSAURID AMPHIBIAN FROM NEW JERSEY

The Metoposauridae were large (alligator-sized) labyrinthodont amphibians that had a cosmopolitan distribution in the latter half of the Triassic Period, being found in both eastern and western United States, eastern Canada, Germany, Morocco, Madagascar, and India (Buffetaut & Martin, 1984). With their flattened skulls and bodies and their feeble legs they were evidently permanent water-dwellers, dieting on fishes. In the Newark Supergroup of eastern North America their latest occurrence is in the Lockatong and New Oxford Formations of Late Carnian age and they seem to have become extinct some time before their puddle-mates the phytosaurs, which survived until nearly the end of the Triassic.

The fragment illustrated in Figure 1 is the first record of a metoposaur from New Jersey. It was found sometime in the early 1950s by a construction worker, Alfonso Robertiello, Jr., who brought it to the Geology Department of Princeton University for identification. Evidently nobody recognized it, for it was filed away without locality data in the sedimentology collection; and I have been unable to locate Mr. Robertiello to obtain further information. The rusty-weathering, buff-colored sandstone is characteristic of the upper Stockton Formation in the vicinity of Princeton; the age indicated is about Middle Carnian, Upper Triassic.

Mr. Robertiello's mysterious specimen (PU 18364) proves to be the natural mold in sandstone of the posterior part of a metoposaurid interclavicle—the large, kite-shaped breastplate that separated the triangular clavicles of the amphibian in life. For comparison, Figure 2 shows the interclavicle in place in a skeleton of the German species *Metoposaurus diagnosticus*. Our specimen displays (in reverse, being a mold) the characteristic surface of metoposaur dermal bones, consisting of round-bottomed pits and semi-segmented channels about 4 mm deep and 5 mm wide between crests. The bilaterally symmetrical, fan-shaped arrangement of the sculpture indicates that this fragment is from an interclavicle rather than a clavicle.

To classify this specimen requires a brief survey of the taxonomy of the Metoposauridae. Basically the family is divided into two genera or genus-groups. In members of the first group, which is typified by the cosmopolitan genus *Metoposaurus* (called *Buettneria* in some older American publications), the back end of the skull on either side is deeply notched by a semicircular embayment that evidently supported the eardrum. This embayment, called the otic notch, is partially enclosed by a triangular projection of the tabular bone that is called the tabular horn. The other group of metoposaurs, represented by *Dictyocephalus* from the Cumnock Formation of North

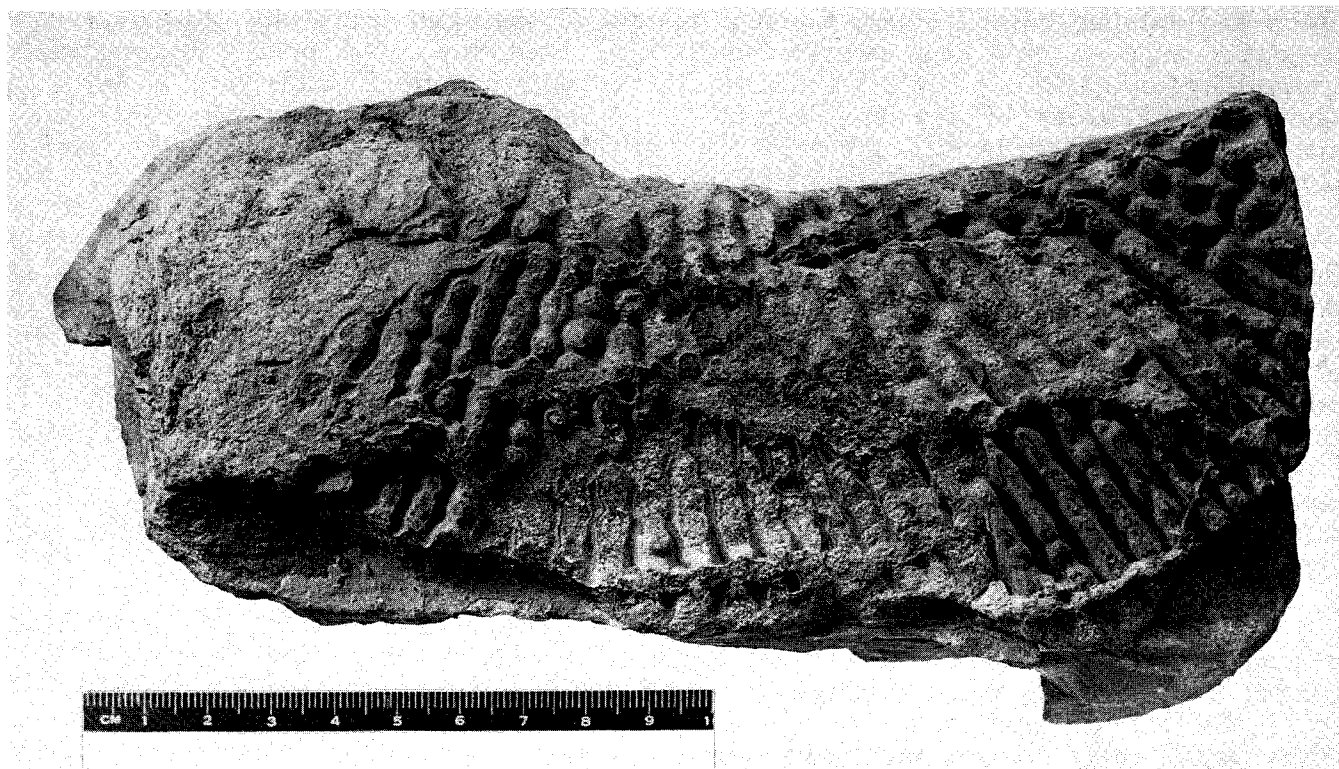


Figure 1. Metoposaurid amphibian, partial interclavicle preserved as a natural mold in Stockton sandstone (PU 18364). Scale in millimeters.

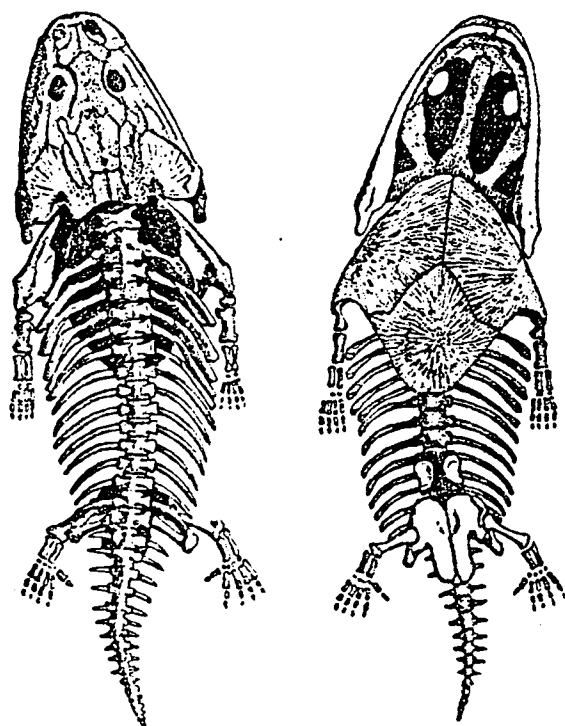


Figure 2. Skeleton of *Metoposaurus diagnosticus* in dorsal and ventral views, showing the breastplate formed by the clavicles and interclavicle; skull length is 45 cm. From the Keuper (Schilfsandstein) of Württemberg, Germany. (From Abel, 1924, after Eberhard Fraas.)

Carolina and *Anaschisma* from the Popo Agie Formation of Wyoming, lacks the otic notch and tabular horn: instead, the rear margin of the skull bears only a shallow sinus on either side, so that the eardrum must have been supported mainly by connective tissue (Gregory, 1980). There are practically no other significant differences between the skulls and skeletons of the two groups. Consequently it is impossible to assign a metoposaur specimen to one group or the other unless the back end of the skull is preserved.

The first metoposaur found in the Newark Basin came from the Lockatong Formation at the Phoenixville Tunnel in Chester County, Pennsylvania, and was described by Edward D. Cope (1866, 1868) under the name *Eupelor durus*. His type specimen (AMNH 3927, labeled as such in Cope's handwriting) consists of the central area of a large skull, from the orbits back to the pineal eye, but it lacks the diagnostic posterior margin. Cope's anatomical analysis of this specimen was excellent, and his comparison of it with the German *Metoposaurus diagnosticus* was right on the button, but without the critical area it cannot be classified below the family level. Recent authors have therefore been forced to reject the name *Eupelor* as a *nomen dubium*, restricting it to the type specimen. Chances are good that *Eupelor* and *Metoposaurus* are synonyms, but we'll never know for sure, so there the matter must rest.

Two other metoposaur specimens from the Cope collection, a left clavicle and an interclavicle (AMNH 1850, 1863), were described by the Freiherr von Huene (1921) as coming from "the Phoenixville tunnel, York Co., Pa." This odd geographic error was not really the baron's fault but was committed by a cataloguer at the American Museum when Cope's collection was purchased from his widow in 1902. The specimens are indeed from York County, but from Charles M. Wheatley's copper mine near Emigsville, and from the New Oxford Formation of the Gettysburg Basin rather than the Lockatong of the Newark Basin. (These specimens were redescribed by Colbert & Imbrie, 1956. The fragmentary interclavicle is very similar to the New Jersey specimen illustrated here.) Other metoposaur material from the Emigsville locality remains unprepared and unstudied in the Wheatley/Cope collection. As with the type of *Eupelor durus*, none of it can be assigned to genus.

The only generically identifiable specimens from the Gettysburg Basin are a fine pair of skulls that were collected in 1970 by Donald Hoff for the William Penn Memorial Museum in Harrisburg, Pennsylvania. These skulls are still being prepared but they are definitely *Metoposaurus*; their source is the "phytosaur hole" on Little Conewago Creek at Zions View, York County, in the New Oxford Formation (Hoff, 1971).

One other identifiable metoposaurid can be reported from the Newark Supergroup: a small skull roof from the Wolfville Formation at Noel Head, Hants County, Nova Scotia, that was discovered by R. William Selden (now curator of the Geological Museum at Rutgers University) on my field trip of 1974. The osteological characters of this skull (PU 21742) place it in the species *Metoposaurus bakeri* (Case), which was originally described from the Dockum Group of Texas. In this species, as in the German species *Metoposaurus diagnosticus*, the prefrontal and jugal bones meet to form the anterior border of the orbit, excluding the lacrimal bone; whereas in the other American species of *Metoposaurus* (including the new skulls from Zions View) the lacrimal enters the orbital margin.

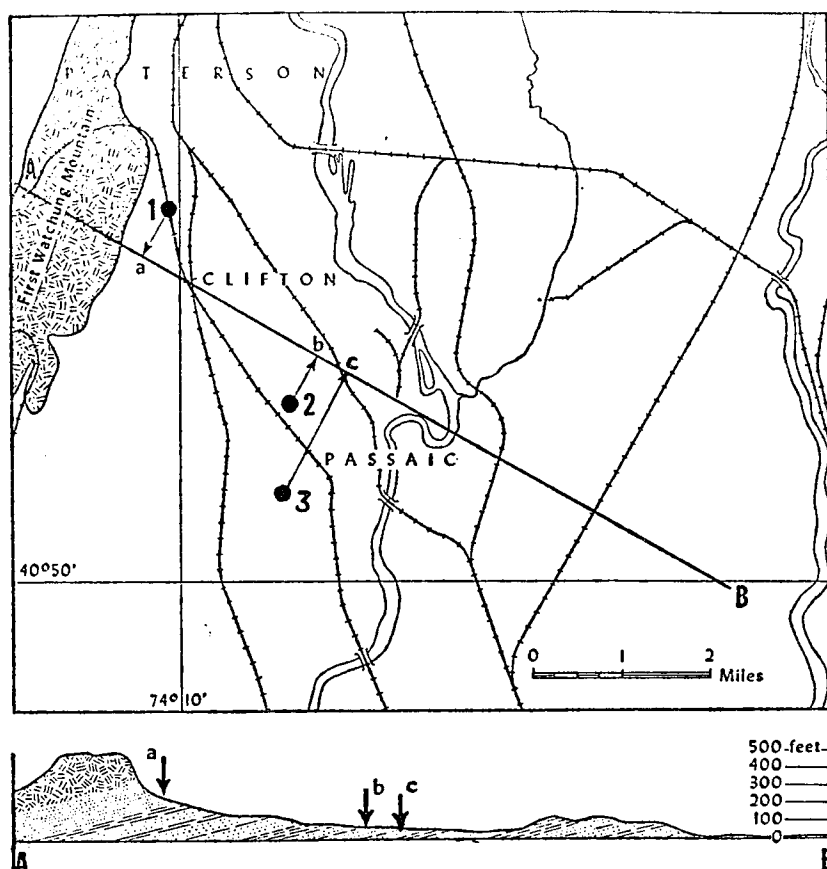
## 2. A SKULL OF *Hypsognathus* AND FOOTPRINTS FROM PASSAIC

On September 1, 1974, Chris Laskowich, a member of the Monmouth Amateur Paleontologists Society and a long-time research associate of the Princeton Museum, was engaged in cutting down a large tulip tree near the corner of Brook and Ridge Streets in Passaic, Passaic County. On one of the coping stones of a low stone wall that bounds the corner property he noticed a partially-eroded skull with two large bony spikes projecting from one cheek. With the kind permission of the property-owner, Mrs. Krauss, Mr. Laskowich and his fellow MAPS member Harold Mendryk dismantled the wall and secured, in addition to the skull, three small slabs containing fossil footprints. These specimens he has generously donated to the museum.

According to Mrs. Krauss, most if not all of the stones in the wall came from the cellar excavation of the house. Their source, then, is the upper part of the Passaic Formation (formerly the Lower Brunswick Formation: Olsen, 1980a). Their age is Late Norian ("Rhaetian" of older works), Late Triassic (Olsen & Baird, in press). The site is just one mile south of the quarry on Paulison Avenue, on the municipal boundary between Clifton and Passaic, from which the American Museum of Natural History had recovered several specimens of the procolophonid reptile *Hypsognathus fenneri* that were described by Colbert in 1946. In the same quarry workmen had earlier uncovered, but unfortunately did not collect, what seem to have been limb bones of a small dinosaur. Relationships of the new site to the Paulison Avenue quarry and the type locality of *Hypsognathus fenneri* are shown in Figure 3.

When found, as shown in Figure 4A, the skull was preserved as a natural mold of the skull table and dorsal surface of the palate. Some white bone in the snout area indicated that the upper part of the muzzle was still embedded in the sandstone block. With so little bone remaining it was decided to sacrifice the rest, leaving a mold from which positive casts could be taken. A synthetic-rubber mold was first made to record the palatal structure, then this area was sacrificed and the remaining bone was removed to reveal the external nostrils and the dorsal surface of the snout. The final stage in preparation is represented by the painted cast in Figure 4B. It can be seen that the cheek spines of the left side have been lost, and the skull roof (with its large central opening for the pineal eye) has been crushed downward and slightly forward between the elongated eye-sockets. In the center of the snout is a crater-like depressed fracture that must have been made by the canine tooth of some carnivorous reptile. Evidently its spikes did not protect our little reptile from being chomped to death.

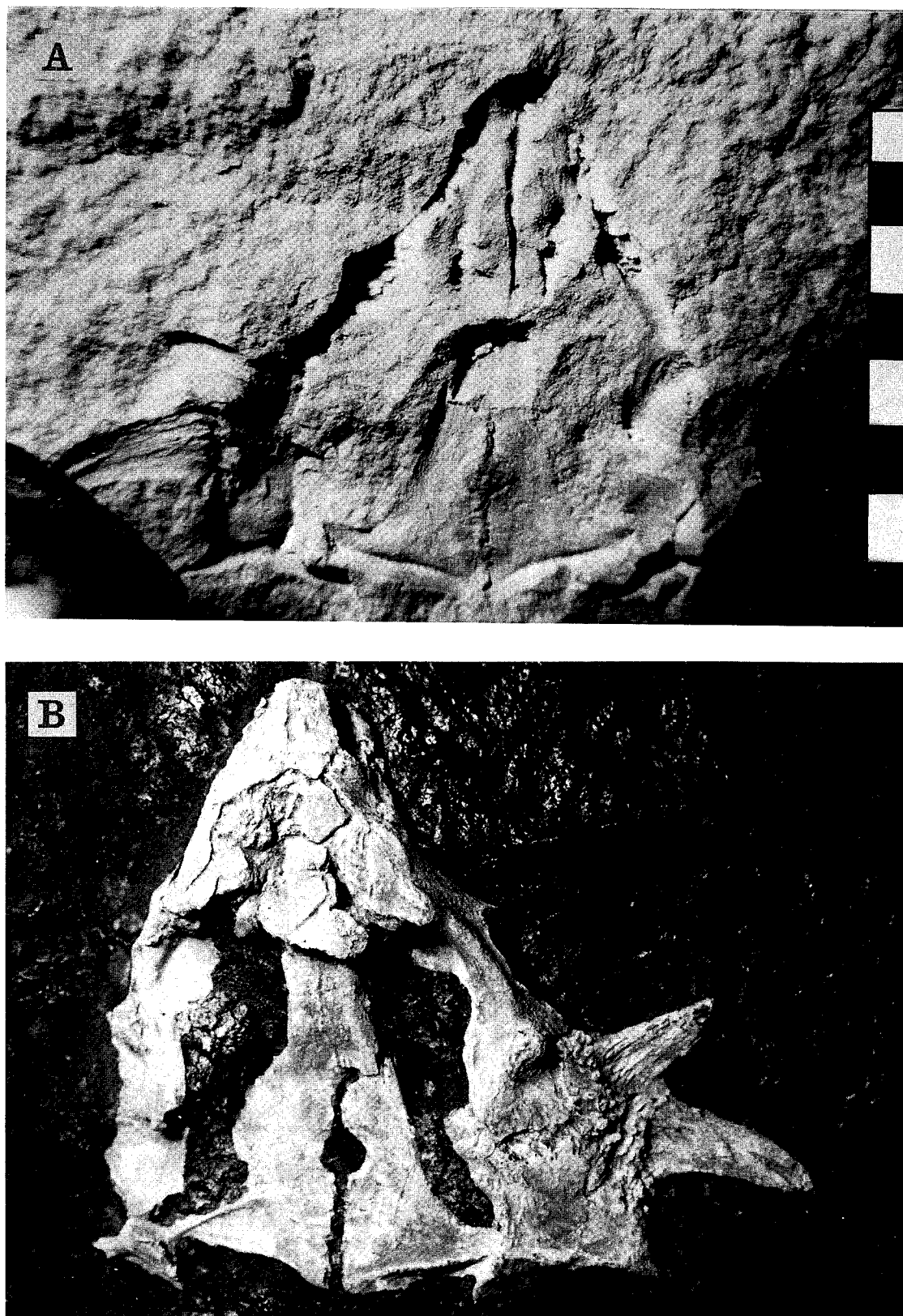
Its keyhole-shaped orbits and spinescent cheek immediately identify the new skull as that of *Hypsognathus fenneri*, a small stem-reptile of the family Procolophonidae that was described by Gilmore (1928) on the basis of a partial skeleton that was excavated from an underpass where Broad Street in Clifton crosses the tracks of the Delaware, Lackawanna & Western Railroad. As the type specimen (USNM 11643) consists only of a natural mold in sandstone of the mandibles and pre-pelvic skeleton in ventral view, Gilmore's description of his new reptile was necessarily incomplete, although he correctly identified it (at least by implication) as a procolophonid. With the subsequent recovery of a skull with partial skeleton and two additional but incomplete skulls (AMNH 1676, 1677, 1678) from the Paulison Avenue quarry it became possible for Colbert (1946) to present a much fuller account of the reptile's anatomy and to point out its relationships within the family Procolophonidae. In the skull, however, some sutural relationships and other osteological features remained obscure because of imperfect preservation and the relative immaturity of the individuals preserved (skull length in AMNH 1676 being only 50 mm). The skull found by Chris Laskowich is substantially larger, with a length (corrected for crushing) of 81 mm, and its suture pattern is fairly clear. In addition it



**Figure 3.** Map and structure section showing *Hypsognathus* localities in Clifton and Passaic, New Jersey (from Colbert, 1946, with additions). 1, type locality of *Hypsognathus fenneri*; 2, Paulison Avenue quarry; 3, corner of Brook and Ridge Streets; a, b, c, projection of these sites onto the line of the structure section A-B. Because of local faulting the stratigraphic relationships are only approximate. The Passaic Formation is capped by the Orange Mountain Basalt flow of First Watchung Mountain; the Triassic-Jurassic boundary lies close below the base of the basalt.

displays the dorsal surface of the palate and other features not preserved in the specimens available to Colbert.

Further information on the pectoral girdle and forelimb of *Hypsognathus* is provided by a partial skeleton (AMNH 5499) found in the excavation for a new high school in Glen Rock, New Jersey, northeast of Clifton and thus off the map in Figure 3 (P. E. Olsen, personal communication). Best of all, in terms of supplying additional information on *Hypsognathus*, is an excellent skull with partial skeleton that was discovered by two youngsters, David Bazzano and Robert Baron, in a stone wall on the outskirts of Meriden, Connecticut. The original source of this YPM specimen is unknown, but it evidently comes from the New Haven Arkose, a correlative of the Passaic Formation of New Jersey (Anon., 1967, 1969). Comparison of Figure 4 with a dorsal view of the Meriden skull, published in Jerry Case's book, *A Pictorial Guide to Fossils* (1982, fig. 27-8), shows that the two are nearly identical in morphology—as they are also in size. These specimens and the one from Glen Rock will be described in detail elsewhere, so further analysis would be inappropriate here.



**Figure 4.** Skull of the procolophonid reptile *Hypsognathus fenneri* from the Passaic Formation of Passaic, New Jersey (PU 21752). *Above*, specimen as found, a natural mold in reddish-brown sandstone with some white bone still in place. *Below*, cast of skull roof after preparation, painted to differentiate matrix from bone impression. Note the depressed fracture in the middle of the snout, evidently caused by a predator's tooth. Scale in centimeters.

The procolophonids were a family of small, evidently herbivorous reptiles that first appeared in the Late Permian and diversified considerably in the Triassic, becoming extinct near the end of the period. For dealing with tough vegetation they evolved jaws with teeth adapted for chopping or grinding. Deep flanges on the pterygoid bones prevented any lateral movement of the mandibles, so the bite was strictly orthal and the upper teeth meshed like cogs with the lowers when the jaws closed. The powerful jaw muscles originated in a pair of temporal openings that extended back from the eye-sockets, giving the latter a keyhole-shaped appearance. One effect of this specialization is that procolophonids generally "died with their teeth clenched," with the happy result that the lower jaws are nearly always preserved in articulation with the skull. Later members of the family, like *Hypsognathus*, tended to develop clusters of bony spikes on the cheeks that afforded them some protection against hungry predators—although the new skull from Passaic demonstrates that this protection didn't always work.

At present *Hypsognathus* is the only genus of procolophonid known from the United States. [The genus *Sphodrosaurus* from the Passaic Formation of Lancaster County, Pennsylvania, was originally assigned by Colbert (1960) to the Procolophonidae, but a fresh look at the unique specimen suggests that it may instead be a rhynchosaurine rhynchosaur. Further preparation and restudy will be necessary to settle the question.] A Canadian *Hypsognathus* was recently discovered by Anson Brown in the upper Wolfville Formation of Nova Scotia (P. E. Olsen, personal communication; AMNH specimen), and four genera of diversely-specialized procolophonids occur lower in the section, in the Grand Pré member of the Wolfville. Three of these are new to science while the fourth appears to belong to the Scottish genus *Leptopleuron* (Baird & Olsen, 1983).

### The Associated Footprints.

Three small slabs bearing fossil footprints were found by Messrs. Laskowich and Mendryk in the same stone wall that yielded the *Hypsognathus* skull. Of the three taxa represented, two are identifiable, and these are different from anything previously reported from the Passaic Formation.

### Ichnogenus *PROCOLOPHONICHNIUM* Nopcsa, 1923

#### *Procolophonichnium* sp.

**Material.** A right manus-pes set imprinted on reddish-brown siltstone (PU 21754, Figures 5, 6B). By bad luck the slab is broken in such a way that no other footprints of the trackway are preserved. The stride must have been greater than 14 cm, measuring from the posterior margin of the pes forward to the slab edge.

**Discussion.** Footprints of this type were first described by Seeley (1904, 1905) from the upper Karoo Supergroup of Middelburg, Cape Province, South Africa, evidently from the Procolophon Zone of the Lower Triassic. Seeley's material was given the ichnogenetic name *Procolophonichnium* by Nopcsa in 1923, and the type species was named *P. nopcsai* by Kuhn in 1963. Unfortunately Seeley's paper was illustrated only with line drawings of the fore and hind feet (not in their natural relationship), and the essential trackway measurements of stride, angular pace, and pace angulation were not stated. In subsequent years authors have assigned to the genus a number of footprints from the Lower and Middle Triassic of Europe. Some of these assignments were





Figure 5. Manus (above) and pes tracks of *Procolophonichnium* sp. from the Passaic Formation of Passaic, New Jersey (PU 21754). Tracks appear in relief because photographed from a latex mold. Centimeter scale approximates the midline of the trackway.

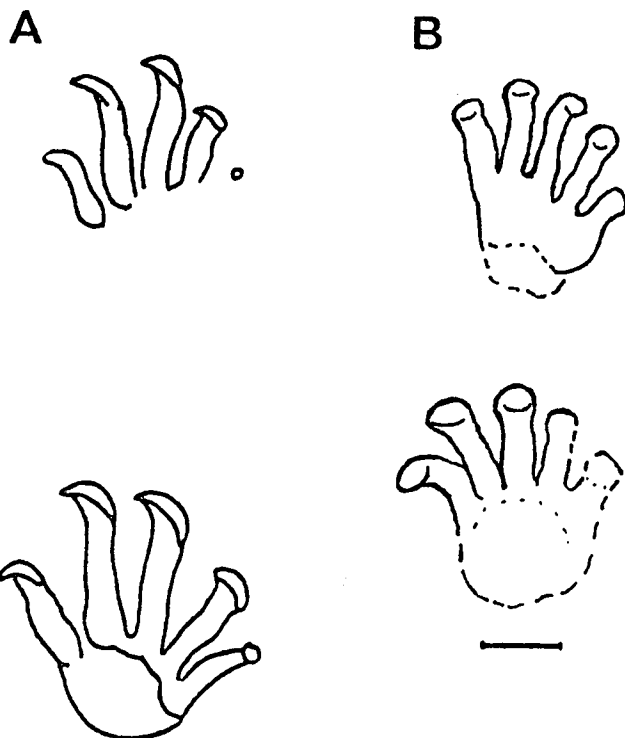


Figure 6. A, *Procolophonichnium winterswijkense*, left manus-pes set, from the Lower Muschelkalk of the Netherlands (from Demathieu & Oosterink, 1983). B, *Procolophonichnium* sp. from the Passaic Formation of Passaic, New Jersey, drawn as a left manus-pes set. Scale bar equals 1 cm.

erroneous or were based on specimens that are really too poor for positive identification, but a few species are soundly established and provide the basis for our understanding of the genus. In the Lower Triassic we have *Procolophonichnium muelleri* Haubold (1970) from the lower Buntsandstein of Meerane, Saxony, and *P. jageri* Demathieu & Muller (1978) from the middle Buntsandstein of Britten, Saarland; in the Middle Triassic we have *P. sp.* Demathieu (1977) from Chasselas (Saône-et-Loire), France, and *P. winterswijkense* Demathieu & Oosterink (1983) from the Lower Muschelkalk of the Netherlands.

Of these species *P. winterswijkense* is most similar to the Passaic specimen in foot morphology (see Figure 6) and in the inferred proportions of the trackway. We are fortunate that the Winterswijk locality has produced a number of good trackways for comparison, and that Demathieu & Oosterink's monograph is generously illustrated with excellent photographs of the material. When allowance is made for the usual variability between individual footprints, the chief distinction of the New Jersey *Procolophonichnium* lies in its having relatively longer fifth digits in both manus and pes. On this basis it probably represents a new ichnospecies—the naming of which is best deferred until its morphology and trackway parameters can be confirmed by additional specimens.

This is the first occurrence of *Procolophonichnium* in the Upper Triassic as well as the first American record of the genus. From the time of its first discovery to the most recent publication by Demathieu & Oosterink, authors have agreed that *Procolophonichnium* should be correlated with the reptilian family Procolophonidae. It seems reasonable to hypothesize, therefore, that the specimen from Passaic represents the footprints of *Hypsognathus*. Confirmation is impossible at present, however, because the manus phalanges and the entire hind foot of *Hypsognathus* are unknown.

#### Ichnogenus *GWYNEDDICHNIUM* Bock, 1952

##### *Gwyneddichnium majore* Bock, 1952

**Material.** A right pes imprint (Figure 7A, bottom); an indistinct pes imprint from another trackway is nearly on the slab (PU 21753).

**Discussion.** Identification was made by direct comparison with Bock's type and paratype specimens (ANSP 15212, 15213) from the Lockatong Formation of Gwynedd, Montgomery County, Pennsylvania. As Bock observed, in this distinctive genus of footprint the pes is larger than the manus, and imprints anterior and lateral to it: evidently the trackmaker's hind limbs were so long that the hind foot regularly overstepped the fore foot. Both manus and pes are pentadactyl, with long, extremely slender toes that are nearly straight, though the claws of the first three toes curve slightly toward the midline of the trackway. The toes are only slightly divergent and the third is longest, the second and fourth being about equal in length. Bock named two other species—*G. elongatum* and *G. parvum*—from the Gwynedd locality, but they differ mainly in size and in accidents of impression, so only the type species need be recognized. Although too much reliance should not be placed on a single footprint, the specimen from Passaic is closely conformable in size and morphology with the type material. To the best of my knowledge this is the first record of *Gwyneddichnium* away from the type locality.

*Gwyneddichnium* is readily distinguished from the somewhat similar ichnogenus *Rhynchosauroides* by its relatively straight, subparallel toes and especially by the shortening of the fourth digit. Whereas *Rhynchosauroides* has typically lacertoid feet and has been interpreted as the footprints of a Triassic lizard or (alternately) of a

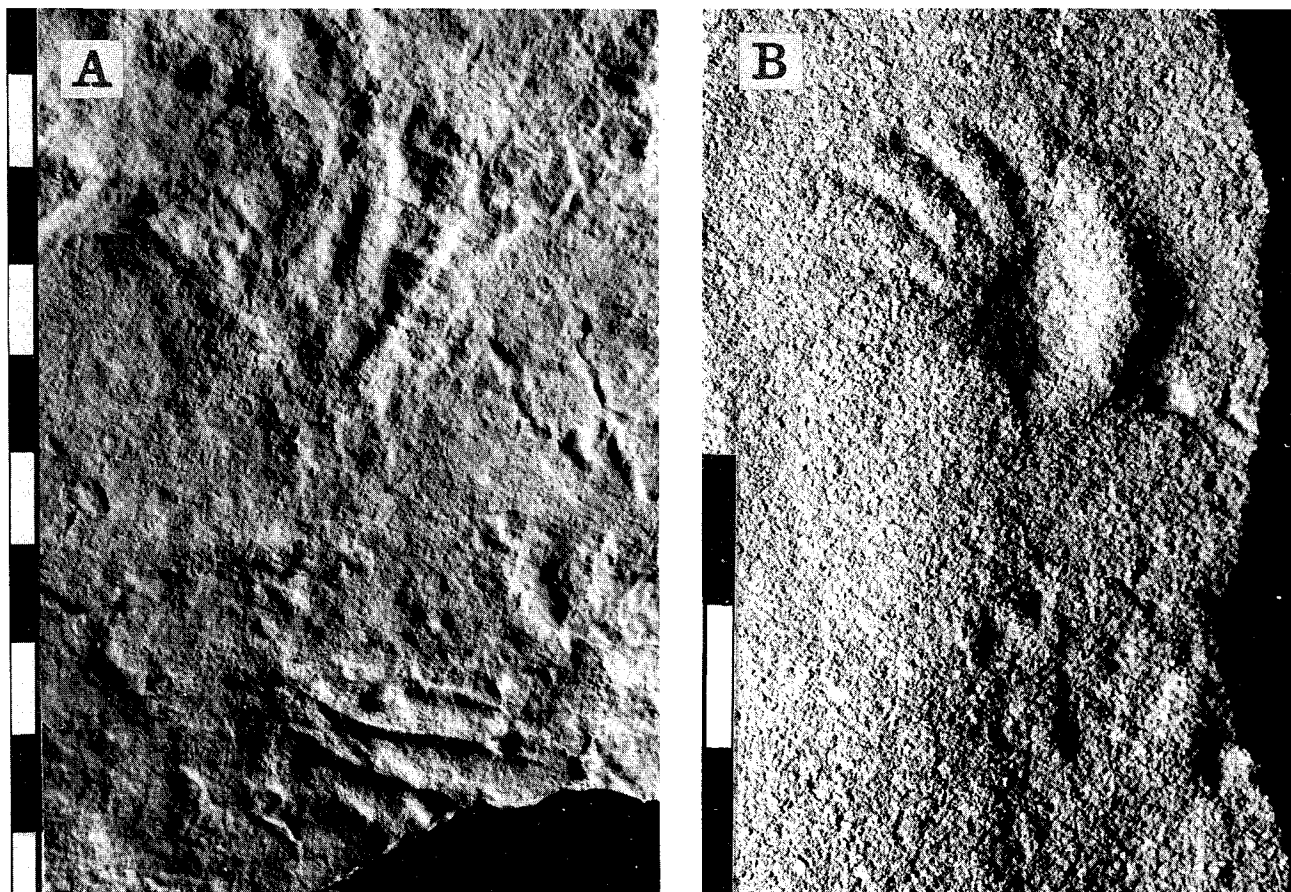


Figure 7. A, *Gwyneddichnium majore*, mold of right pes track headed right, at bottom of slab; obscure footprint above (PU 21753). B, indeterminate lacertoid footprints on sandstone (PU 21753A). Both from the Passaic Formation of Passaic, New Jersey. Scales in centimeters.

sphenodontid rhynchocephalian (Baird, 1964), the short fourth toe of *Gwyneddichnium* represents a derived condition. As Bock pointed out, nothing quite like it had ever been described. After surveying the Triassic reptiles that were known at the time he concluded that the trackmaker might have been a small pseudosuchian.

More recently, however, Paul E. Olsen (1979) has described a small Triassic reptile that makes a nearly perfect correlative for *Gwyneddichnium*: the eosuchian *Tanytrachelos ahynis*. This is a more primitive American cousin of the bizarre, long-necked European genus *Tanystropheus*, and like it belongs to the family Tanystropheidae. First found in the Cow Branch Formation (Late Carnian) on the Virginia-North Carolina border, *Tanytrachelos* soon turned up in substantial numbers in the lower Lockatong Formation of New Jersey and southeastern Pennsylvania (Olsen, 1980b). Olsen's revised reconstruction, based on excellent articulated skeletons, shows *Tanytrachelos* to have feet that closely match the *Gwyneddichnium* footprints and a walking gait in which the hind foot overstepped the forefoot. More detailed comparisons will appear in Olsen's projected monograph on the new *Tanytrachelos* material. In the meantime this paper gives me the opportunity to announce that the origin of *Gwyneddichnium* footprints is no longer an enigma.

## Ichnogenus Indeterminate

The footprints illustrated in Figure 7B (PU 21753A) were impressed on a sandy rather than a muddy surface and consequently show too little morphological detail to permit reliable identification. They are included here partly for the sake of completeness, partly as an example of the quality of footprints to which names should *not* be applied. Ichnology, the study of fossil footprints, is a legitimate scientific field that has much to contribute to the paleontological and biostratigraphic records. Unfortunately the field has been given a bad name by the propensity of so many authors, over the past 150 years, to bestow Latin names on hopelessly indeterminate specimens—and sometimes to compound the fault by drawing biostratigraphic conclusions from such material.

## 3. THE PHYTOSAUR JAW FROM BELLEVILLE, AND PHYTOSAUR FOOTPRINTS

In 1895 Arthur M. Edwards, M.D., reported in the *American Journal of Science* on some fossils he had recently found in the Triassic sandstones on the west side of the Passaic River in Essex County, New Jersey:

"For several years I have carefully watched the quarries where the Newark (Jura-Triassic) sandstone was taken out at Newark, Arlington and at Belleville.... Today at the Belleville Quarry, just north of the city of Belleville, I was gratified to see some traces of larger fossils revealed in the lower levels of the quarry. These were Ornithichnites [i.e., three-toed dinosaur tracks]; a track of what is evidently Brontozoum with two of the joints well marked. A third is not so well marked. There are two nails of the foot evident. It is in a red shale which formed from fine-grained mud.... Last month I secured a jaw bone in excellent preservation with the teeth gone. It looks like the *Dromatherium sylvestre* of Emmons...."

Dr. Edwards donated his jaw bone to the Peabody Museum of Yale University, where it was catalogued as YPM 3772. In due course it came to the attention of Yale professor Richard Swann Lull, who identified it as the phytosaur *Rutiodon* and mentioned it briefly in his monograph on the Triassic life of the Connecticut Valley (Lull, 1915, pp. 79-80). He noted, "This specimen, consisting as it does of a portion of the skull without the teeth, was said by Edwards to 'look like *Dromatherium sylvestre* of Emmons.' It is quite evident that Edwards never saw the minute jaw of the mammal *Dromatherium* or he would never have made such a comparison."

Although Dr. Edwards' jaw was the first fragment of a phytosaur ever found in New Jersey, it has never been described or illustrated, and authors other than Lull have ignored it. My purpose here is to document it for the record. As shown in Figure 8 the specimen consists of a partial right maxilla, embedded in reddish-brown sandstone with its dorsal side uppermost but with most of the bone exfoliated. It is truncated anteriorly by a transverse fracture of the block and posteriorly by a low-angle break that appears to follow, in part, the suture between the maxillary and palatine bones. Five empty tooth sockets are preserved, of which the most anterior, about 8 mm in transverse diameter, is the smallest. The maximum width of the fragment is 50 mm as measured at the level of the penultimate alveolus. The postero-medial edge is fluted ventrally for sutural articulation with the palatine, and the antero-medial edge shows similar traces of the premaxillary suture. Between these two sutural edges the medial margin appears to show a finished edge about 12 mm long, which I take to be the edge of a palatal vault into which the internal nares open.

This specimen is clearly phytosaurian, but generic identification is made difficult by the fact that the corresponding area of the maxilla is infrequently preserved in phytosaur skulls. It is missing or obscure in the described skulls of *Rutiodon carolinensis*, the species which (on grounds of distribution) is most likely to be represented by the Belleville specimen. In the type skull of *Rutiodon* [*Machaeroprotopus*] *adamanensis* (Camp, 1930, p. 37, pl. 1) a close correspondence can be seen, and Camp states that the "palatal portions of maxillaries form the external anterior borders of internal nares," as they do in the Belleville maxilla. This evidence tends to confirm Lull's identification of the specimen as *Rutiodon*.

Lull was understandably puzzled by Dr. Edwards' comparison of the Belleville jaw with *Dromatherium sylvestre*, for two specimens could hardly be more unlike. *Dromatherium* is a tiny, inch-long lower jaw with teeth, found in the Cumnock Formation of North Carolina and described by Ebenezer Emmons (1857) as a mammal, although it is now known to be a mammal-like reptile. I suspect, however, that

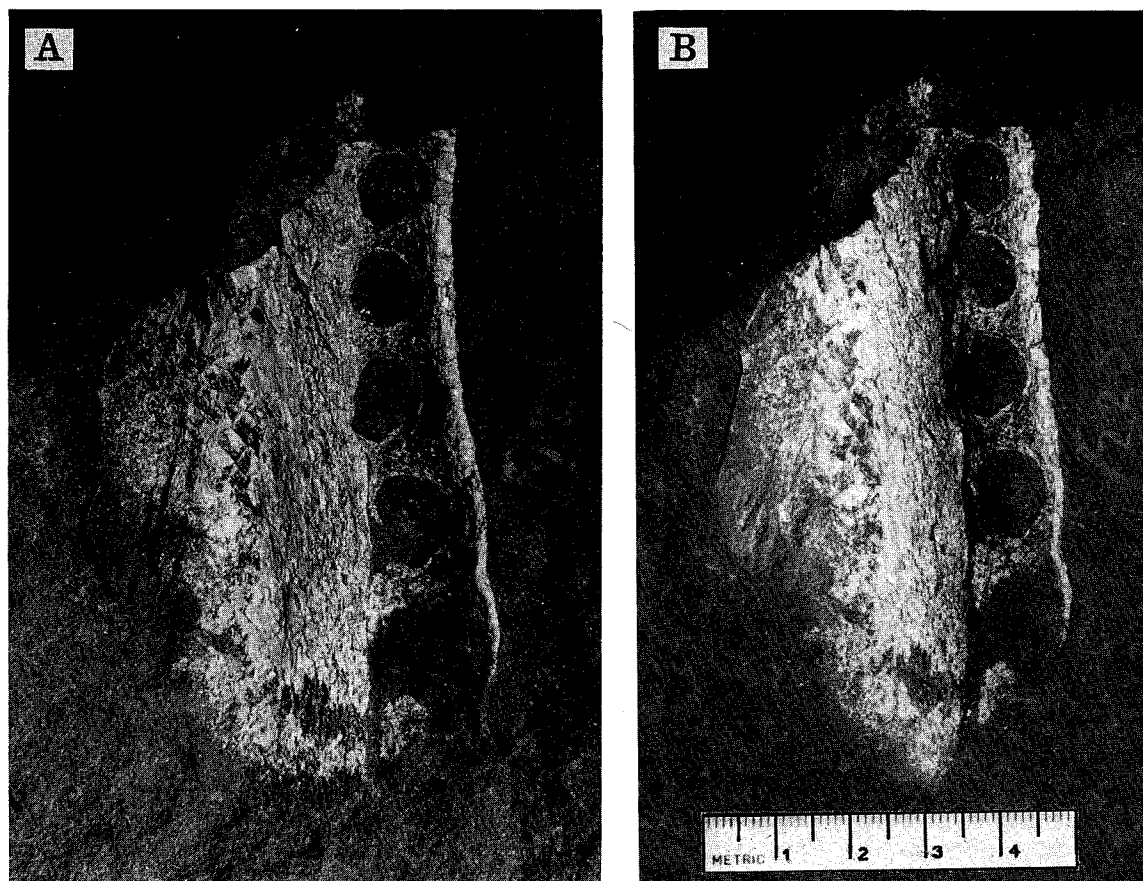


Figure 8. *Rutiodon* sp. from the Passaic Formation of Belleville, New Jersey: partial right maxilla in dorsal view (YPM 3772). A, specimen on slab as preserved; B, maxilla rotated into the frontal plane, showing the palatal process with (on left edge) part of the margin of the internal naris. Scale in millimeters.

Edwards' mention of *Dromatherium* was a slip of the pen, and that what he really had in mind was another North Carolina specimen described in the same book: the type of *Palaeonornis struthionoides* Emmons (Figure 9). The strong resemblance of the latter to the jaw from Belleville is no coincidence. Once the New Jersey specimen is identified, it is easy to see that the North Carolina specimen consists of the posterior part of the rostrum of a phytosaur seen in palatal view, with the teeth missing from their sockets and the outer edges of the premaxillary bones broken away.

Emmons, however, identified *Palaeonornis* as a portion of the sacrum of "a large, heavy bird" that had six sacral vertebrae coalesced together. He went on to compare it with the ostriches and suggested a correlation with the well-known "bird" footprints of the Connecticut River Valley. Of course his anatomical identification was totally mistaken, but the correlation was not unreasonable at a time when three-toed dinosaur footprints were universally believed to have been made by giant birds.

Unfortunately the true nature of *Palaeonornis* was a long time in catching up with it. Described as a bird, it was subsequently considered only by bird specialists—who found it very dubious indeed. Alexander Wetmore (1929, p. 380) called it "so doubtfully avian as not to merit consideration at this time." Kalman Lambrecht's monumental *Handbuch der Palaeornithologie* (1933, p. 647) quoted Wetmore and noted that *Palaeonornis*, if legitimate, would be the oldest known bird. In his 1956 check-list Wetmore again cited it as "Affinity doubtful: possibly not avian." Fearing that this pseudo-bird might wander indefinitely in the limbo of *incertae sedis*, in 1974 I sent word to Pierce Brodkorb, knowing that he was in the process of compiling a comprehensive catalogue of the fossil birds of the world. Presumably, then, *Palaeonornis* will be officially de-feathered as a junior synonym of *Rutiodon carolinensis* in the final section of Brodkorb's work, the section dealing with taxa that have been wrongly assigned to the Class Aves. So closes one of the little comedies in the history of paleontology.

The stratigraphic position of the Belleville Quarry appears to be near the middle of the Passaic Formation, i.e., about midway between its contact with the underlying Lockatong Formation and the overlying Orange Mountain Basalt that forms First Watchung Mountain. The reddish-brown sandstone quarried there was the "brownstone" so dear to architects of the Victorian era.

Subsequent finds of phytosaur material in New Jersey make a short list. The second specimen to be discovered was a large but unfortunately headless skeleton (AMNH 4991) that was excavated from the Stockton Formation, about 20 feet below the Palisades Diabase, on the west bank of the Hudson River near Fort Lee in Bergen County. This was described in 1913 by the Freiherr von Huene, who noted slight differences from *Rutiodon carolinensis* and accordingly made it the type of a new species, *Rutiodon manhattanensis*—a name that betrays the good baron's vagueness about minor points of American geography. In 1918 an equally large but fragmentary skeleton (PU 11544), this one from Little Conewago Creek at Zions View in York County, Pennsylvania, was assigned to *R. manhattanensis* by William J. Sinclair. That made two nominal species of *Rutiodon*, distinguished mainly by size. However, in 1970 Donald Hoff of the William Penn Memorial Museum reopened the old excavation at Zions View (Hoff, 1971) and took out, along with additional pieces of Sinclair's phytosaur, two skulls that appear to be *Rutiodon carolinensis*. The better of these is only 60 cm long. So it seems that either the two species cohabited in York County or, more plausibly, that specimens assigned to *R. manhattanensis* are better regarded as big bulls of *R. carolinensis*. A firm decision on this point of synonymy, however, must await the full preparation and analysis of the new skulls from Zions View.



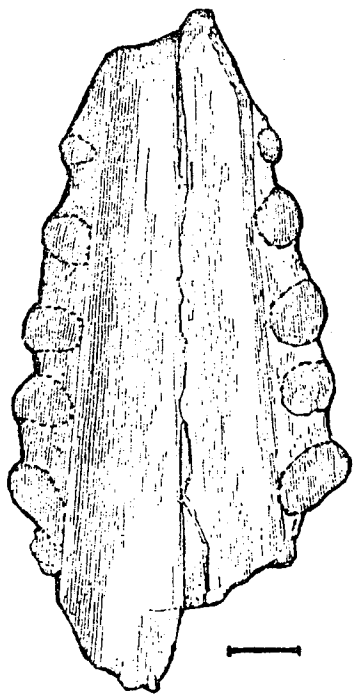


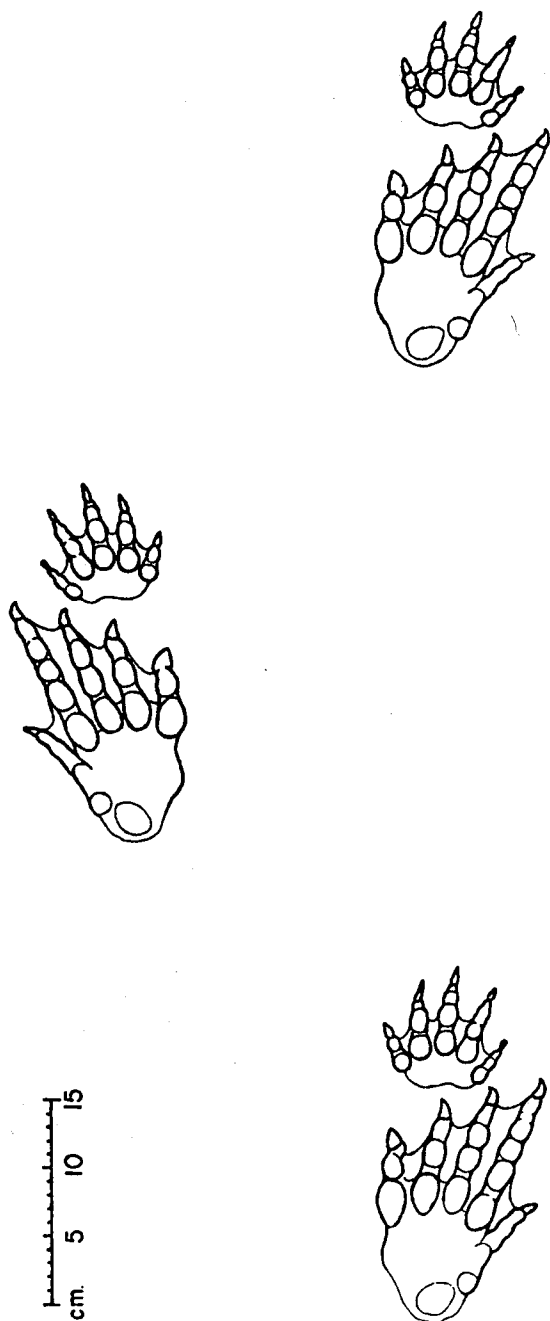
Figure 9. Type specimen of *Palaeonornis struthionoides* Emmons, the supposed sacrum of an ostrich-like bird (from Emmons, 1857; specimen unlocated). Reinterpreted as a rostrum fragment, in ventral view, of the phytosaur *Rutiodon carolinensis*. From "the red and variegated sandstones of Anson County, North Carolina," now designated the Pekin Formation. Scale bar equals 1 cm.

A much more instructive specimen is a small skull (about 48 cm long) with associated osteoscutes (AMNH 5500) that was discovered by Robert M. Salkin in the Lockatong Formation at Granton Quarry in North Bergen, Hudson County. Presented to the American Museum by its collector, this specimen was described by Edwin H. Colbert (1965) and assigned to *Rutiodon carolinensis*. An isolated posterior tooth from an animal of about the same size (PU 18259) was collected from the Lockatong along with thousands of specimens of the coelacanth fish *Diplurus newarki* in the excavation for Firestone Library on the Princeton University campus (Colbert, 1965). A single dorsal osteoscuta of the *Rutiodon* type (PU 17060) was found in 1960 near the top of the Stockton Formation in the excavation for Wilcox Hall on campus. Paul E. Olsen (personal communication) has noted phytosaur teeth at a number of New Jersey localities in the course of his Triassic explorations, but few if any of these specimens have been collected.

## Phytosaur Footprints

Additional evidence for phytosaurs in this state consists of the fossil footprints named *Apatopus lineatus* (Bock), from which one can deduce a skeletal structure and body proportions that correlate well with those of *Rutiodon* (Baird, 1957; Figure 10). This ichnogenus was described originally from the Perkasio Member of the Passaic ("Lower Brunswick") Formation at Milford, Hunterdon County. In 1971 Neal K. Resch discovered additional tracks of *Apatopus* (PU 23643, 23644), along with dinosaur and

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**Figure 10.** Phytosaur trackway, the type specimen of *Apatopus lineatus* (Bock), reconstructed from adjoining slabs in the Lafayette College and Harvard collections (LC S490 + MCZ 212, from Baird, 1957). Collected by John Eyerman in 1885–1887 from the Perkasio Member of the Passaic Formation in the Clark Quarry, just north of Milford, Hunterdon County, New Jersey. The foot structure is a composite drawn from all specimens, as individual tracks seldom show so much detail.



chirothere footprints, in the Ukrainian Member of the Passaic in a cut on Interstate Route 280 behind the old Second Precinct Station in Newark, Essex County. Figure 11 shows a good partial trackway of *Apatopus lineatus* (PU 21235) that was bulldozed to light in 1971 by John L. Cannon in a cut made for Route I-280 in Llewellyn Park, West Orange, Essex County. The slab was collected for Princeton by Robert M. Salkin and Neal K. Resch. Coming as it does from near the top of the Passaic formation, this specimen constitutes the youngest known occurrence of phytosaur material in New Jersey. These footprint records and their stratigraphic significance are discussed in greater detail by Olsen & Baird (in press).

In this case as in others, the footprints provide information about a long-extinct animal that could not be obtained from skeletons alone. Although the trackway pattern shows general similarities to that of early crocodilians (Olsen & Padian, in press), the foot structure is decidedly non-crocodilian. The fifth toe of the hind foot is well-developed and functional instead of being reduced to a rudiment enclosed in a heel-pad, as it is in Early Jurassic crocodylomorph tracks such as *Batrachopus*. The fourth hind toe is the

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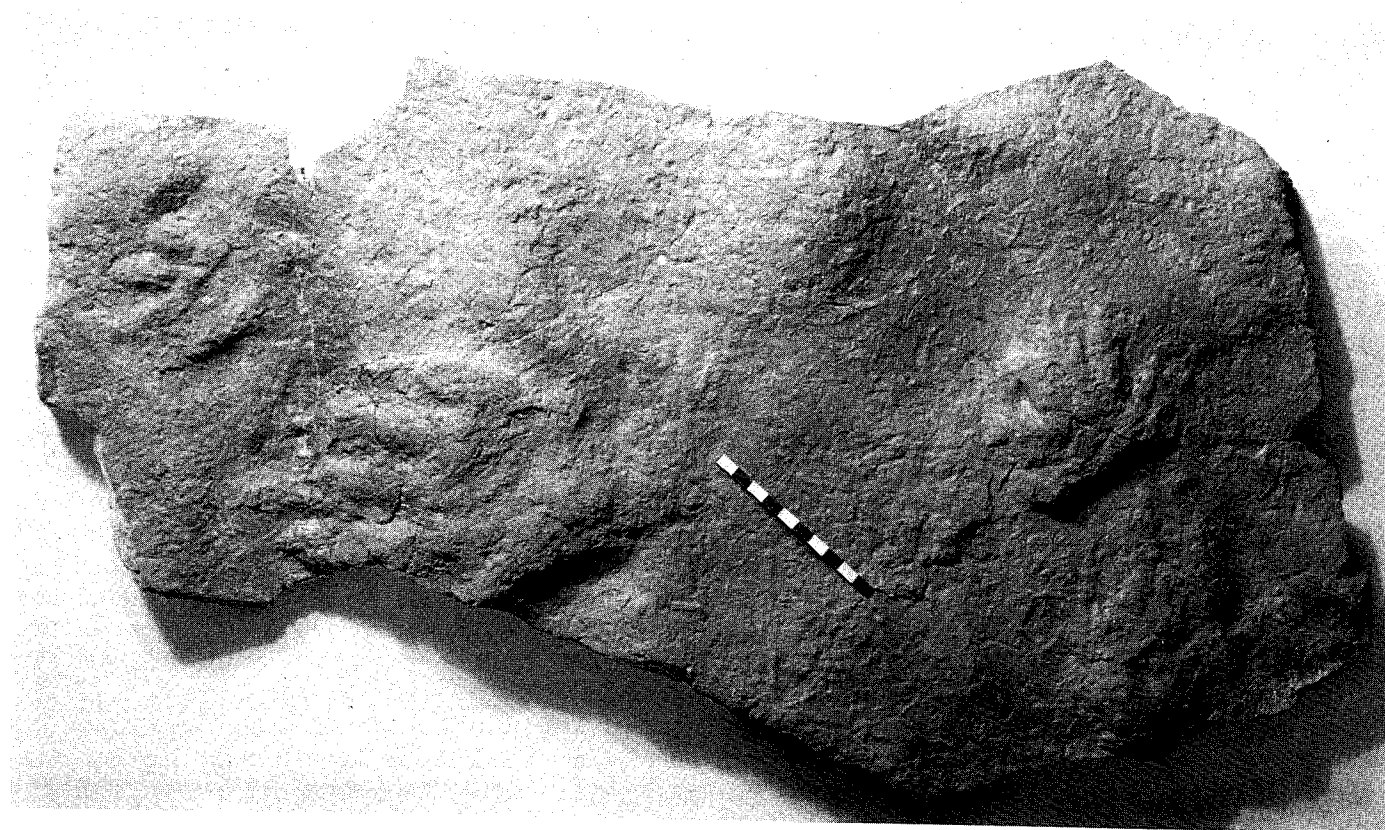


Figure 11. *Apatopus lineatus*, phytosaur trackway of two manus-pes sets (PU 21235) from the upper Passaic Formation at Llewellyn Park in West Orange, New Jersey. The centimeter scale marks the midline of the trackway.

longest (and actually shows hypertrophy of the phalanges) instead of shorter than the third; and webbing connects the bases of the claws instead of being deeply recessed between the toes as it is in living crocodiles. The hind foot of *Apatopus* was obviously adapted for active swimming, whereas living crocodiles when swimming tend to tuck the hind limbs back and propel themselves with the tail alone. In the walking trackway of *Apatopus* the front foot points forward, unlike crocodiles which walk with the front feet rotated outwards. In phytosaurs the external nostrils open upward and are positioned on a mound just in front of the eyes, rather like the periscope and snorkel of a submarine, whereas the nostrils of crocodilians lie out at the end of the snout. These very different ways of adapting to a similar mode of life account for the name "false crocodiles" that is sometimes applied to phytosaurs—though it would be just as appropriate to call the crocodiles "false phytosaurs." After all, the crocodilians seem to have moved into the aquatic niche only after it had been vacated by the phytosaurs, which became extinct for unknown reasons close to the Triassic-Jurassic boundary.

#### 4. THE ARMORED REPTILE *Stegomus arcuatus*

What is undoubtedly the most outstanding reptilian fossil ever found in the Passaic Formation of New Jersey was the discovery of some youngsters from Frenchtown, Debbie, Robert, and Roy Kerr and their cousin James Smith. In 1971, while hiking along Nishisakawick Creek in Alexandria Township, Hunterdon County, they spied a curious impression on the surface of a block of brown sandstone in the creek bank. With much effort the boys carried the heavy rock back to their mother, Mrs. Donna Kerr, who appreciated its significance and began consulting various scientists to get an identification. No positive answer was forthcoming, although one geologist seems to have mistaken the specimen for a 365-million-year-old trilobite. (A trilobite from an area mapped as Triassic?) Finally Mrs. Kerr brought the find to the attention of Richard E. Hartten, the enterprising editor of the *Hunterdon Review*, who ran a front-page article on the mystery fossil. By coincidence Mr. Hartten had been consulting me about a mastodon skeleton recently discovered in the area, so he sent along a professional photo of Mrs. Kerr's specimen as well . . . and the mystery was solved. Mrs. Kerr very generously donated the specimen to the Princeton museum, where it has been catalogued as PU 21750.

As shown in Figure 12, the specimen consists of a natural mold of the upper surfaces of the skull and armored thorax of a reptile. In the abdominal area is a loose fragment of internal mold, oval in cross-section, that reproduces on its upper surface the inner sides of the dorsal armor plates and on its lower surface the inner sides of the belly-plates. Superimposed on the latter is a series of chevrons that represent the gastralium or abdominal ribs of the reptile. In normal position on the upper surface of the stone is a mold of the left fibula in articulation with its femur, which disappears into the block, where the pelvis is presumably buried. On the heavily weathered edge of the block can be seen a partial mold of the right femur and the edges of other elements including a neural arch. All of the exposed bone has been removed by weathering although the bone in the interior is evidently still intact. To expose the concealed parts it will probably be best to crack off the matrix in pieces and eliminate the adhering bone with needles and acid, leaving a negative impression from which positive casts can be taken with liquid rubber. Obviously a full description of the skeleton will have to wait until this delicate preparation has been carried out.

The specimen's source has been relocated, with the help of the finders, by my colleague David C. Parris of the New Jersey State Museum: it lies 0.6 mile east-northeast of the center of Everittstown, at the point where Nishisakawick Creek swings close to Route 513 (the Everittstown-Pittstown road). On the geological map by Drake, McLaughlin & Davis (1961) its stratigraphic position is seen to be low in the Passaic ("Brunswick") Formation, below the Graters Member.

The identification of this remarkable fossil takes us back to 1896, when O. C. Marsh described a similarly-preserved specimen that had been discovered by Freeman Clark in his quarry at Fair Haven, within the city limits of New Haven, Connecticut. The sandstone in which it occurred is now called the New Haven Arkose and is correlated with part of the Passaic Formation (Olsen *et al.*, 1982). Professor Marsh's specimen (YPM 1647) consists of a natural mold of the inner surface of the dorsal thoracic armor, with the dorsal (paramedian) and most of the dorsolateral plates in essentially normal articulation. These eighteen bands of scutes covered the neck and about three-quarters of the trunk. Also preserved (but never yet illustrated) are two chunks of the counterpart block with natural molds of the upper surfaces of several plates, both dorsal and dorsolateral. Each band of bony plates overlapped the one behind it, allowing for

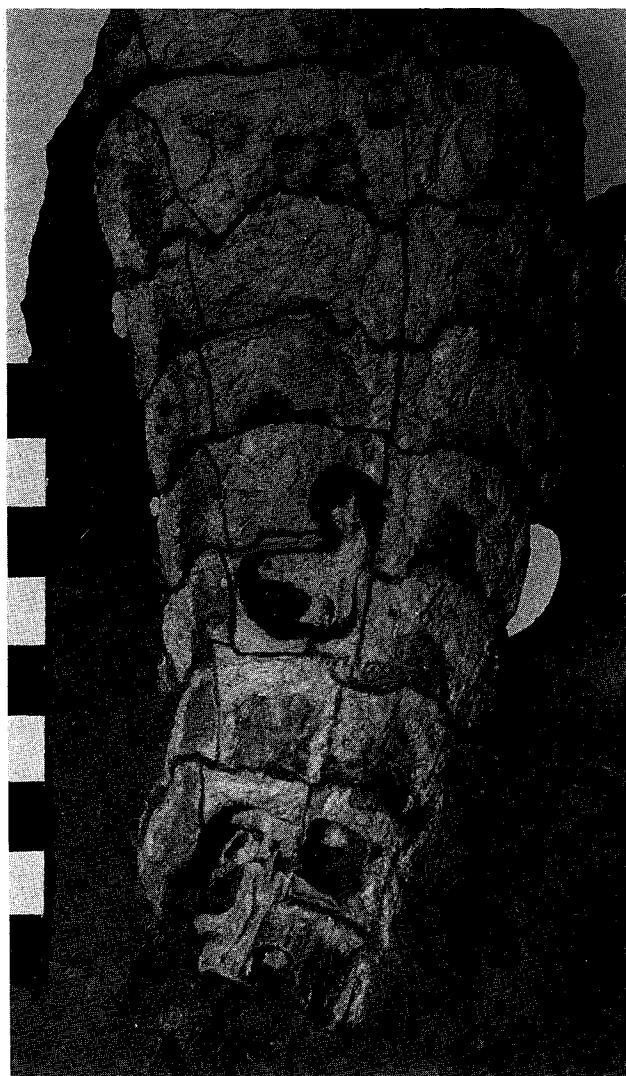


Figure 12. *Stegomus arcuatus*, natural mold in sandstone of juvenile skeleton in dorsal view (PU 21750). Pelvis concealed under matrix at bottom; fibula and end of femur at lower right. Triangular block at left, removed from abdominal area, shows chevron pattern of gastral plates overlying shingled belly-armor. Scale in centimeters.

considerable flexibility in life: in the New Haven specimen the armor sheathing is strongly arched from front to back, whereas in the Nishisakawick specimen the corresponding area is flexed in the opposite way, giving it an unnaturally swaybacked appearance. As in the living crocodilians, each osteoscutum was originally capped by a horny epidermal scute that has not been preserved.

Marsh made his specimen the type of a new genus and species, *Stegomus arcuatus*. The generic name meaning "armored mouse" may allude to the specimen's resemblance to a chiton, the *mus marinus* of Pliny, or alternatively to the armored shed called a *musculus* with which Julius Caesar assaulted the walls of Gallic towns. Marsh correctly placed *Stegomus* among the thecodont reptiles and pointed out its resemblance to the German genus *Aetosaurus*; however, he was mistaken in assigning it to the "Belodontia" or phytosaurs, which we now know to have been armored thecodonts of a different sort.

The second specimen of *Stegomus arcuatus* came to light just 40 years later, in a house excavation about 1.25 miles southwest of Neshanic Station in Somerset County, New Jersey. Its stratigraphic position is low in the Passaic Formation. As shown in Figure 13, this specimen (NJSM 10740) includes nine segments from the proximal part of the tail, preserved in three dimensions although somewhat compressed dorso-ventrally. Each segment comprises four pairs of bony plates—dorsal, dorsolateral, ventrolateral, and



**Figure 13.** Partial tail of *Stegomus arcuatus* from the Passaic Formation near Neshanic Station, New Jersey (painted cast of NJSM 10740). Windows have been cut in some dorsal osteoderms to expose parts of three caudal vertebrae. Scale in centimeters.

ventral—forming a ring that surrounds one caudal vertebra. Three of these vertebrae can be glimpsed through windows that were painstakingly excavated through the armor by preparator Frank N. Goto. As the specimen has been thoroughly treated in an excellent paper by Glenn L. Jepsen (1948), further description is unnecessary. My only exception to Jepsen's treatment is to point out that his erection of a new subspecies, *Stegomus arcuatus jerseyensis*, was quite unwarranted on zoological or geological grounds. Although there is no anatomical overlap between the parts of the animal preserved in YPM 1647 and NJSM 10740, or between the latter and PU 21750, the three specimens are alike in the shapes and sculpture of their dermal plates and can be reasonably assigned to the same species. Paleontological subspecies, however, should be based on populations of individuals and not on isolated and fragmentary specimens.

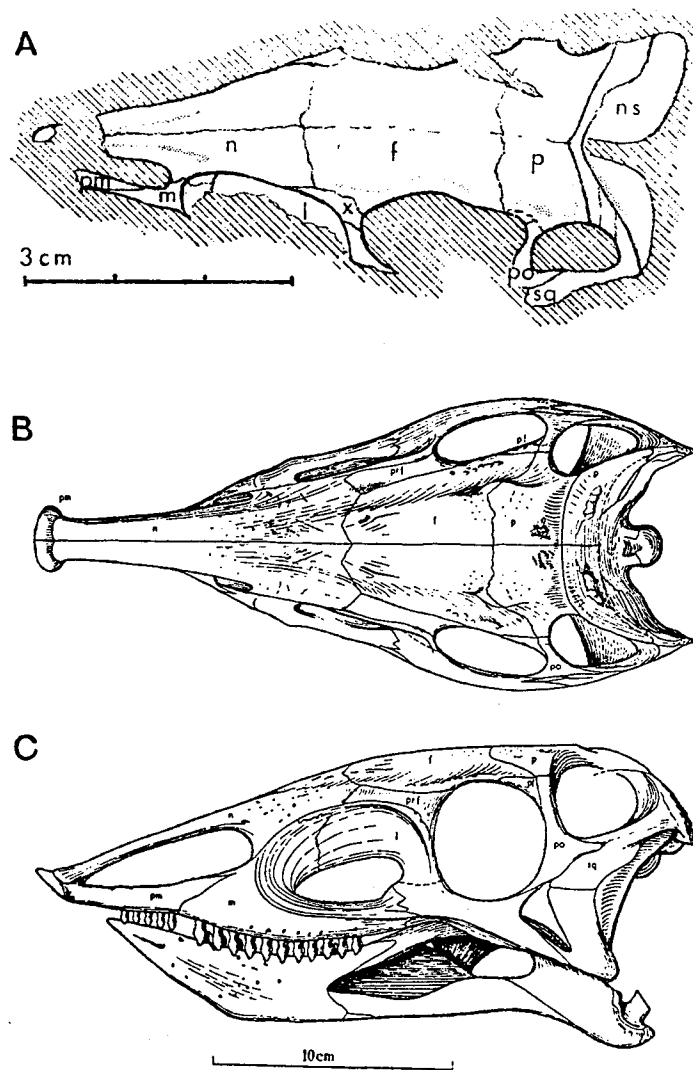
Parenthetical mention may be made here of a fourth (and still undescribed) occurrence of *Stegomus*, for information about which I am indebted to Paul E. Olsen. The specimen, a three-dimensional section of tail much like the one from Neshanic Station, was found in 1965 by Alvis Hargraves, a workman in the Triangle Brick Company's pit-mine in western Wake County, North Carolina. It is preserved in the collections of the Geosciences Department of North Carolina State University in Raleigh.

### The Skull of *Stegomus*

The *Stegomus* from Nishisakawick Creek is particularly instructive in being the first specimen to include skull material: the skull roof with the upper part of the cheek. It will be most convenient to describe this with reference to the skull of the closely-related reptile *Stagonolepis robertsoni* from the Triassic of Elgin, Scotland, which has been monographed admirably by Alick D. Walker (1961). When comparing the two, as in Figure 14, we must keep in mind that the *Stagonolepis* depicted is an adult individual, whereas the *Stegomus* is quite immature—indeed, it is the next-to-smallest-known individual of the family. Allowance must therefore be made for proportional changes that would be expected to occur as the result of allometric growth between the juvenile and the adult conditions. Note also that the description and figure are taken from latex casts made from the natural mold shown in Figure 12, so the features are reversed left-for-right in comparison to the mold.

The skull has been compressed obliquely so that the left cheek is everted toward the plane of the skull roof while the right cheek is folded under. The smooth-surfaced roofing bones are molded to the underlying brain, with the cerebral and cerebellar areas expressed as low domes. Around the lateral and nuchal margins of the skull roof runs a sinuous, shallow, round-bottomed sulcus. A series of openings occupies most of the cheek surface: the elongate external nostril, a very large antorbital fenestra, the orbit (which has the large size to be expected in a big-eyed juvenile), and the temporal fenestra. Most of the occipital surface of the skull is obscured by the first pair of nuchal osteoscutes.

Although the tip of the snout is broken, the posterior end of the left premaxilla is preserved in articulation with the maxilla, forming the lower border of the external nostril. No teeth, unfortunately, are exposed on either bone. The tip of the right premaxilla lies isolated but apparently in approximately its natural position; it appears not to be broadened like the snout-tip of *Stagonolepis*. The nasals are narrow right triangles that become rodlike anteriorly. The relatively long frontals form most of the upper margin of the orbit, and are separated from the margin of the antorbital fenestra by a small prefrontal. What can be seen of the lacrimal forms the dorsal rim of the antorbital fenestra and the anterior margin of the orbit; its forward contact with the maxilla is more guessed-at than seen. The parietals are short, and their roof exposure is terminated at the rear by an obtuse-angled nuchal crest, beyond which their occipital



**Figure 14.** A, juvenile skull of *Stegomus arcuatus* as preserved, from a latex cast of PU 21750. B–C, adult skull and jaw of *Stagonolepis robertsoni* in dorsal and lateral views, as reconstructed by Walker (1961). Abbreviations: f – frontal, l – lacrimal, m – maxilla, n – nasal, ns – nuchal scute, p – parietal, pf – postfrontal, pm – premaxilla, po – postorbital, prf – prefrontal, sq – squamosal, x – prefrontal.

surfaces slope downward abruptly. A pillar-like postorbital separates the orbit from the temporal fenestra; its upper end may incorporate a small postfrontal that is not otherwise distinguishable. Breakage on the posterior corner of the skull obscures the relationship between parietal and squamosal, but the latter bone is seen to swing forward, forming the ventral margin of the temporal fossa and underlapping the posterior process of the postorbital.

## Relationships of *Stegomus*

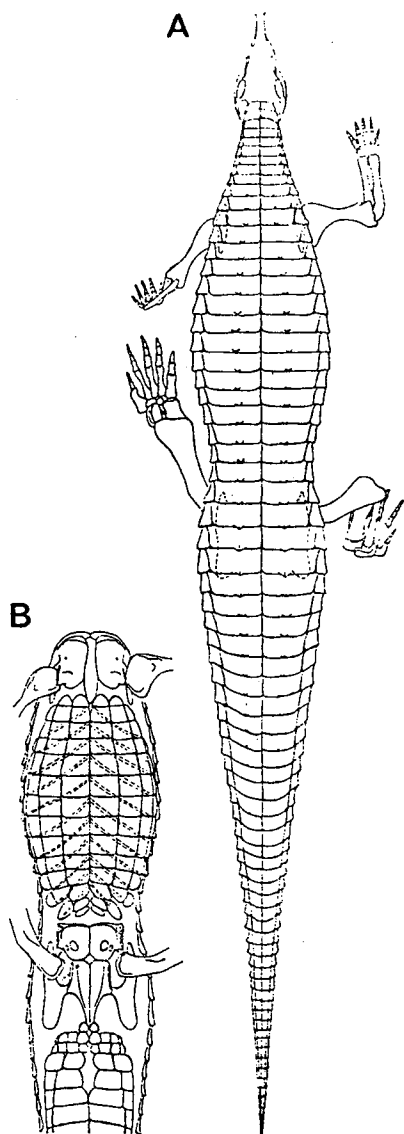
Without going into the complicated taxonomic history of the armadillo-reptiles we can say with confidence that *Stegomus* belongs to the family Aetosauridae (of which *Stagonolepidae* is a junior synonym), an assignment that was first made by O. P. Hay (1902). Such has been the reasoned consensus of recent authors, but the fortunate presence of a partial skull in the specimen from Nishisakawick Creek now provides solid confirmation. As a group the aetosaurs are most closely related to the carnivorous rauisuchids, the crocodilians, and the phytosaurs, so these four lineages can be brigaded together as a crocodylomorph group within the Archosauria. The formerly-used term "pseudosuchian" has been largely abandoned as being a wastebasket category, and "thecodont" is now used merely as a descriptive term for reptiles with socketed teeth.

Although the present treatment is preliminary rather than definitive, a comparison of new and old material now permits us to define *Stegomus* as a genus and distinguish it from other aetosaurs such as *Aetosaurus* from the middle Stubensandstein of Germany, *Stagonolepis* from the Upper Triassic of Scotland, *Aetosauroides* from the Ischigualasto beds of Argentina, and *Typothorax* from the Dockum Group of Texas. Distinguishing features of *Stegomus* can be seen in its skull and particularly in the sculpture of its dermal armor and the shape of its tail.

**Skull.** As shown above, the juvenile skull conforms well to the aetosaurid pattern; its proportional differences are more likely to reflect immaturity than taxonomic distinction. The skull roof is broad as in most other aetosaurids, not narrow as in *Aetosauroides*. [Huene's (1920) narrow-roofed reconstruction of *Aetosaurus* is belied by the specimens.] The tip of the snout, like *Aetosaurus* but unlike *Stagonolepis*, is not laterally expanded.

**Dorsal osteoscutes.** In his original description of *Stegomus* Marsh (1896) observed that "the upper surface of the plates was rugose, but not deeply sculptured, being less marked in this respect than in the other known species of Belodonts. The rough surface preserved shows no regular pattern of ornamentation . . . ." He cited this feature as a diagnostic character of *Stegomus*. On the tail segment from Neshanic Station, as Jepsen (1948) observed, most of the bony substance of the dorsal plates has exfoliated, but in the few remaining patches of dorsal surface the sculpture consists of very shallow punctations and grooves. The same appearance (on a miniature scale) characterizes the specimen from Nishisakawick Creek. This feeble sculpturing contrasts with what we find in *Aetosaurus ferratus* (Fraas, 1896), *Stagonolepis robertsoni* (Walker, 1961), *Aetosaurus scagliai* (Casamiquela, 1961, 1967), and *Typothorax meadei* (Sawin, 1947), in which each dorsal osteoscutum bears a sunburst pattern of conspicuous pits and grooves. Walker has noted that in *Aetosaurus* the ornament is most deeply incised in the armor over the pelvis, becoming fainter anteriorly and posteriorly; but nowhere on the specimens illustrated by Fraas is it as subdued as it is in *Stegomus*. I therefore conclude that Marsh was right, and that "subdued to obsolescent sculpture on dorsal osteoscutes" is diagnostic of *Stegomus*.

**Tail shape.** The tail of *Aetosaurus* is long and tapers evenly from base to tip. In reconstructing *Stagonolepis* (Figure 15) Walker had no caudal segment with more than seven vertebrae, but the evidence led him to follow the *Aetosaurus* pattern. In *Stegomus*, on the evidence of the specimen from Neshanic Station (Figure 13), the tail tapers more rapidly and presumably was relatively shorter than in the European genera. This tendency is carried to an extreme in *Typothorax*, where (as reconstructed by Sawin) the tail tapers so abruptly that it appears Y-shaped in dorsal view. *Stegomus*, then, represents an intermediate condition. The centra of its caudal vertebrae, as noted by



**Figure 15.** *Stagonolepis robertsoni* as reconstructed by Walker (1961) with armor in place. *A*, dorsal view; *B*, ventral view of trunk and base of tail. In *B* note the chevron pattern of gastralia, seen also in Fig. 12. Length of a large individual, 120 cm (9 feet).

Jepsen, are broader than those of the other genera cited. This condition cannot be the effect of dorso-ventral compression (as suggested by Walker) because the neural and haemal arches have not collapsed.

### Size and Appearance in Life

To estimate the size (or sizes) of *Stegomus* from the incomplete specimens on hand requires a bit of extrapolation from other members of its family. *Aetosaurus ferratus* is represented by a swarm of articulated skeletons (Fraas, 1896) that provide a good suite of measurements; to these can be added the much larger type specimen of *A. crassicauda* (Fraas, 1907) which may be conspecific with them. We have no complete individual of *Stagonolepis robertsoni* but Walker has successfully reconstructed its skeleton with some



borrowing from *Aetosaurus* (see Figure 15). The individuals of *Aetosaurus* show a considerable range in size, and those of *Stagonolepis* fall into two size-groups that Walker very plausibly attributes to sexual dimorphism. Our three specimens of *Stegomus arcuatus* differ greatly in size, but the type specimen from New Haven and the juvenile from New Jersey provide measurements that can be used to make a rough computation of how large they were in life. Table 1 gives some selected measurements or estimates from which extrapolations can be made.

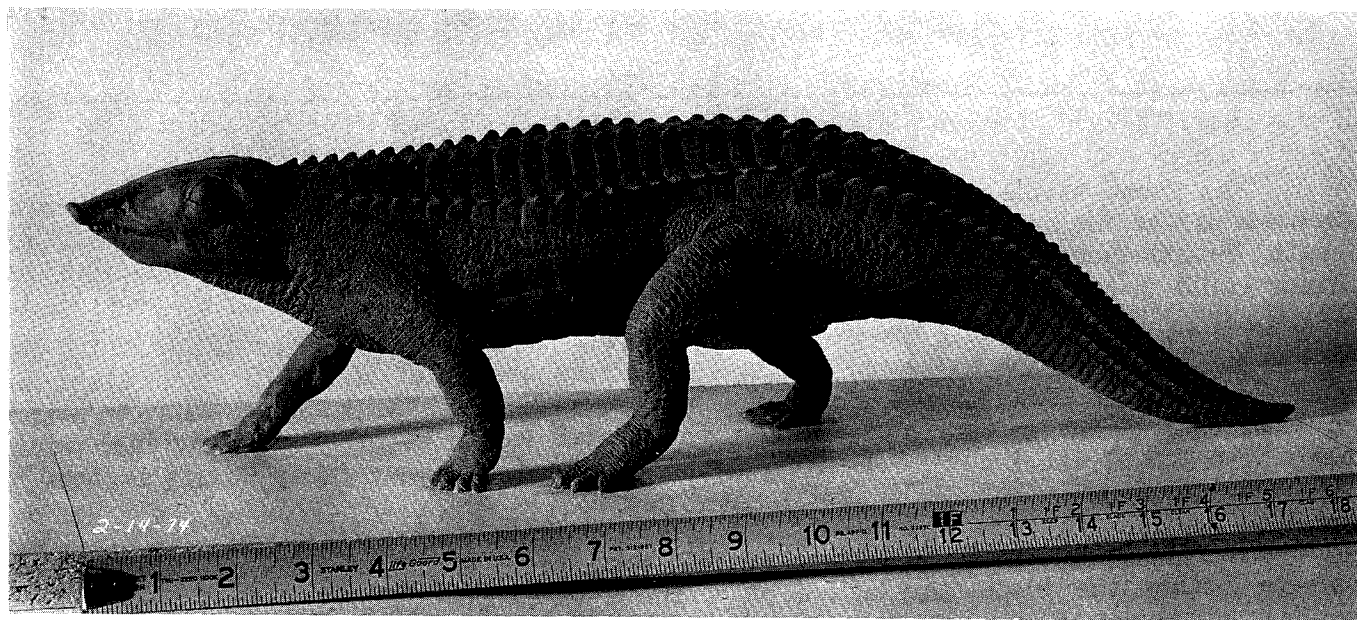
Table 1. Selected dimensions of aetosaurs, measured or estimated(\*), in centimeters. From Walker (1961) and specimens.

|                                       | <u><i>Aetosaurus</i></u><br><u><i>ferratus</i></u>       | <u><i>Stagonolepis</i></u><br><u><i>robertsoni</i></u> | <u><i>Stegomus arcuatus</i></u><br>YPM 1647      PU 21750 |       |
|---------------------------------------|----------------------------------------------------------|--------------------------------------------------------|-----------------------------------------------------------|-------|
| Length overall                        | *120 <u><i>crassicauda</i></u><br>86 mean<br>36 smallest | *270 Large Group<br>*210 Small Group<br>*102 smallest  |                                                           |       |
| Length, snout to sacrum               |                                                          | *120 Large Group<br>93 Small Group                     |                                                           | *22.5 |
| Width, dorsal scute pair,<br>mid-back | 9.5                                                      | 30 Large Group<br>24 Small Group                       | 19                                                        | 6     |
| Length, skull roof in<br>midline      | 9.7 mean                                                 | *24.5 Large Group<br>19 Small Group                    |                                                           | 6     |

The most stable measurement we can make on the type specimen of *Stegomus arcuatus* is the maximum width across the dorsal (paramedian) series of osteoscutes. (A length measurement would be less reliable because of the way the imbricated rings of armor could telescope as the back flexed.) In this dimension YPM 1647 is seen to be smaller than the small size-group of *Stagonolepis*. By slide-rule computation from the figures in Table 1 it would have a snout-to-sacrum length of about 75 cm. Assuming that the tail was roughly 20% shorter in *Stegomus*, so that the snout-to-sacrum length equalled that of the sacrum plus the tail, the overall length of the type individual would have been about 150 cm or 5 feet. This is a good deal shorter than Marsh's guess of "eight or ten feet."

On the specimen from Nishisakawick Creek we can estimate the position of the sacrum within the block and arrive at a snout-to-sacrum length of 22.5 cm. By a similar extrapolation we get an overall length of about 45 cm or 18 inches. The imprecision of these calculations should be obvious, but they give us at least a general idea of the sizes in life of the largest and smallest individuals of *Stegomus arcuatus*.

Thanks to the new specimen and to Walker's invaluable work on the Aetosauria as a group, it is now possible to restore with some confidence the appearance of *Stegomus arcuatus* in life. Such a restoration has been commissioned by the William Penn Memorial Museum in Harrisburg as a part of a projected, full-scale paleohabitat diorama of the Late Triassic fauna of Pennsylvania. Working directly from a cast of the Nishisakawick Creek specimen and supplementary information provided by me, sculptor Chester Kirk of the Richard Rush Studio in Chicago has modeled the juvenile *Stegomus* as shown in Figure 16. After looking at so many pictures of unsatisfying fossils the reader may be gratified to see one of them interpreted as a living animal, and perhaps be tempted to speculate on its way of life. The form of the teeth and their wear-facets, along with the relatively small size of the head, implies that the aetosaurs were herbivorous or (more probably, I believe) omnivorous; and the toothless snout, especially as developed in *Stagonolepis*, suggests an instrument for grubbing and perhaps burrowing. These features, plus the cuirass formed by rings of bony plates that were covered in life by horny scutes, are irresistibly reminiscent of the armadillos (*Dasypodidae*) and may indeed indicate a similar mode of life. We must note, however, that the ventral armor would have prevented a curl-up maneuver like that practiced by armadillos. In any case their extensive sheathing of armor must have afforded the inoffensive aetosaurs some protection against contemporary predators—among which were small carnivorous dinosaurs, large rauisuchid thecodonts, and phytosaurs if the latter occasionally foraged on land. Although their forelimbs were shorter than the hind (as is typical of early archosaurs) there is no doubt that the aetosaurs were habitually quadrupedal and terrestrial reptiles. So we may imagine our little *Stegomus* trotting over the floodplains of Passaic time, pausing to poke his snout into every *Scoyenia* burrow in the hope of finding a luscious crayfish that could be rooted out and devoured.



**Figure 16.** Life-sized restoration of the juvenile *Stegomus arcuatus* from New Jersey, sculptured from the specimen with missing parts restored after *Stagonolepis*. Model made under my direction by Chester Kirk for the Richard Rush Studio, Chicago. Scale in inches. Photograph courtesy of Richard Rush Studio.

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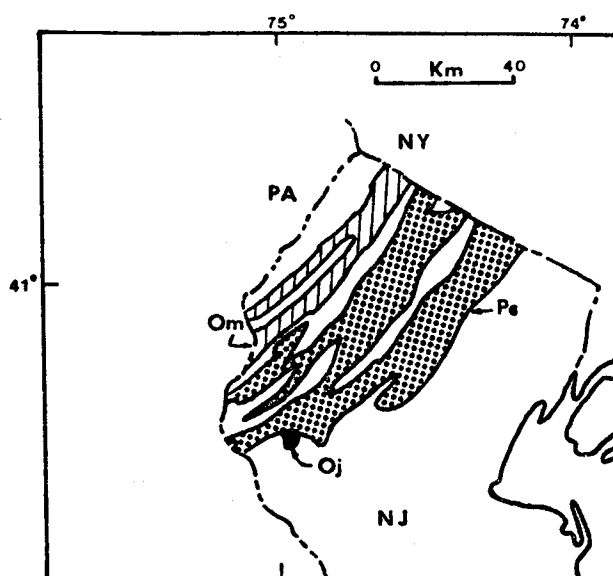


Figure 1. Map showing the location of the Jutland klippe with respect to the Reading prong and the main outcrop belt of the Martinsburg Formation.

|     |                       |
|-----|-----------------------|
| Om  | Martinsburg Formation |
| Oj  | Jutland klippe        |
| PC- | Reading prong         |

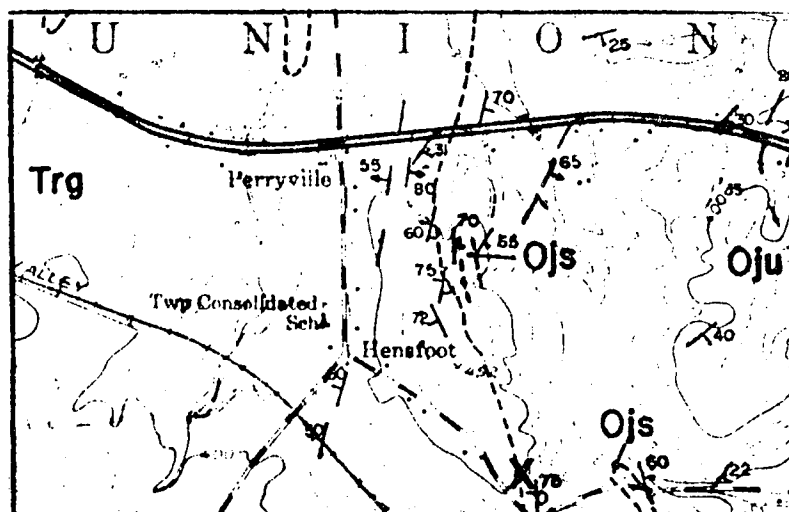


Figure 2. Reproduction of a portion of the High Bridge quadrangle as mapped by Markewicz (unpublished) with Union Township Municipal Building locality indicated (X). Units used by Markewicz were then considered to be the Martinsburg Formation, there designated the Jutland member of the Martinsburg Formation. Other studies in the vicinity of Jutland suggest that the term Martinsburg Formation should not be applied to rocks of the Jutland area. We advocate the designation of local lithic terms for the sequence, but do not propose any new terms.

|     |                                                   |
|-----|---------------------------------------------------|
| Oju | Jutland member                                    |
| Ojs | Jutland member, sandstone and conglomerate facies |
| Trg | Triassic conglomerate                             |

The locality is on the contact between Ordovician and Triassic rocks as mapped by Markewicz.

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